# PATENT SPECIFICATION

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COMPLETE SPECIFICATION

## Steam Spraying

We, E.I. DU PONT DE NEMOURS AND COMPANY, a corporation organised and existing under the laws of the State of Delaware, of Wilmington, Delaware, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to an improved method for the application of coating compositions and more particularly to a method of applying coating compositions by spraying, using steam as the propellant.

It is conventional in the art to apply enamels, paint, lacquers, and similar organic finishes by spraying. The spraying of coating compositions previously heated to reduce their viscosity or to melt the composition is also known, for instance, heating the paint reservoir, heating the liquid supply lines, flame spraying, and metal spraying.

The invention has as its principal objective the provision of a means of applying heavy films of enamel, lacquer, varnish, or the like to all types of substrates in one single-step application procedure without "sagging" or "popping."

Another object is providing a method of applying a high-solids content or high viscosity fluid coating without thinning it to conventional spraying viscosity.

A further object of this invention is the elimination of the costly step of thinning enamel, lacquer, varnish or the like, prior to its application by spraying.

Another object is preventing the costly loss of expensive solvents, used to thin coating compositions for spraying, by eliminating their use or reducing to a minimum the quantities required.

A still further object is providing means for applying enamel, lacquer, varnish or the like, at "package viscosity," the consistency at which it can most conveniently be manufactured, packaged, shipped, and handled by the ultimate user prior to application.

Another object of this invention is a substantial reduction in the fire hazard attendant to painting procedures by materially reducing the quantity of volatile combustible substances used.

These objects are accomplished essentially by substituting superheated steam at 10° to 60° F. of superheat, for all of the atomizing air supplied to the spray gun of the conventional type designed for applying relatively low viscosity enamels, lacquers, varnishes, and the like at conventional spraying pressures. The hot steam discharged under pressure from a conventional spray tip or nozzle heats the relatively viscous fluid coating composition, supplied to the nozzle by suction, gravity or secondary air pressure, and temporarily reduces its viscosity, consistency, or fluidity. Simultaneously the steam atomizes the fluid coating composition and projects it, in the form of a mist, onto the surface being coated in such a manner that the process, visually, is very similar to the air-atomized spraying in conventional finishing procedures.

As far as we are aware, the use of superheated steam in connection with spraying organic finishes appears to be new. One's first reaction to the idea is almost always the question of what happens to the water resulting from condensation since in conventional paint spraying apparatus, water traps or separators are standard equipment because water droplets can adversely affect the appearance and protective qualities of the coating by leaving irregularities. On first analysis, even to one skilled in the art, it would appear that steam as a replacement for the atomizing air for a spray gun would aggravate this water

problem. However, as will be explained later, the behavior of steam is such that the water problem can be overcome.

Much attention has been given by industry to the problem of applying a protective-decorative coating of lacquer, enamel, varnish or the like, to all types of substrates in one operation. One-coat finishing systems are known and in everyday use, particularly on articles which are coated primarily for decorative purposes. However, on many other articles the protective nature of a film is of primary importance, for instance, on refrigerators, automobiles, washing machines, etc., where the article must be protected from deterioration by handling and the like, chemical corrosion, wear, and weather. In these cases, also one-coat finishing systems as such are not new, but usually it is found that there is considerable room for improvement in the protective qualities of the coating, largely due to its relatively low film thickness. The relatively thin film results from a definite limit on the amount of coating composition, thinned for application, that can satisfactorily be put on. A heavier film would afford more protection, but involves "sagging," "popping," or the application of additional relatively thin coats, with interposed drying or baking periods, resulting in a considerable increase in the cost of coating the article, additional handling, drying, and interim storage facilities. "Sagging" is the irregular running or flowing of a coating composition in waves or "curtains" often encountered with heavy coats on vertical surfaces. "Popping" is encountered particularly in heavy coats of lacquers and baking enamels where "craters" or other irregularities are caused by bubbles wholly or partially entrapped in the film during drying or baking. Using faster evaporating solvents to overcome "sagging" often results in increased "popping." Using a slower evaporating solvent to eliminate "popping" often increases "sagging." The simultaneous elimination of both in heavy coats has long been a problem in the finishing industry. "Flash" coating and "flash" baking (applying a thick film in a relatively short time in successive thin coats) can be considered a one-operation painting process, but it involves several separate steps, several individual coats, considerable duplication of equipment and much rehandling of the article.

By way of illustrating this invention, the following examples are given, of which Example I shows the results of conventional air-spraying application, and Example II the results of application using superheated steam.

### Example I.

A white refrigerator top coat enamel consisting essentially of a finely divided prime pigment uniformly dispersed in a vehicle consisting of a solution of a urea-formaldehyde type resin and an oil-modified alkyd resin in hydrocarbon and alcohol solvents thinned with about 15 volumes of hydrocarbon solvent to 100 volumes of enamel, to yield a thinned enamel with a viscosity suitable and generally used for spray application.

The enamel was supplied to the spray gun from a conventional pressure pot under about 8 to 10 pounds per square inch gauge air pressure. Atomizing air was supplied to the spray gun through suitable strainers and water traps at about 60 pounds per square inch gauge.

One coat of the thinned enamel was sprayed onto a vertical metal panel in a manner common in industrial finishing procedures by a skilled operator to a maximum safe wet film thickness, beyond which "sagging" or running of the wet enamel would occur. The enameled panel was then baked in an electrically heated oven for 30 minutes at 280° F.

The resultant enamel film was between 1 and 1.5 mils (0.001 to 0.0015 inch) thick. It was smooth, uniform and glossy in appearance.

Attempts to produce single-coat films from this thinned enamel at a dry film thickness of about 2 mils (0.002 inch) in a quick industrial manner resulted in both "sagging" and "popping" which were visible after baking. The results were unsatisfactory for industrial finishing purposes.

### Example II.

Exactly the same enamel as in Example I was used as follows:

The relatively viscous enamel at its original, manufactured viscosity was applied using the same spray gun with the same nozzle, needle, and tip. The gun handle was wrapped with tape and the operator wore thick gloves, both measures being designed to provide heat insulation.

The relatively viscous enamel was supplied to the spray gun from the pressure pot under about 10 to 15 pounds per square inch gauge air pressure. The increase in pressure over Example I was necessary to force the higher viscosity enamel to the gun. The atomizing air used in Example I was eliminated completely and steam was used as a 100% replacement. This steam, at a pressure of 125 pounds per square inch gauge, passed through a thermally insulated conventional system of separators, strainers, and

traps, and a valve to reduce the steam pressure to about 70 pounds per square inch gauge in which condition its temperature was about 314° F. The atomizing air hose of the spray gun was attached to this source of steam. In place of the composition of the above examples, others containing nitrocellulose, oleoresinous varnishes water insoluble, vinyl resins, phenol-formaldehyde resins and other water insoluble synthetic and natural resins may be used in exactly the same manner.

The relatively viscous enamel was sprayed onto a vertical metal panel. Condensed water droplets were present in the spray pattern and they caused bubbles and splatters in the wet coat of enamel. which remained after the baking operation. The results were unsatisfactory by industrial finishing standards.

A superheater was installed to eliminate the condensed water droplets in the spray. It consisted of a single vertical loop. containing about 6 linear feet of 18—8 stainless steel tubing 0.25 inch O.D. and 0.014 inch wall thickness, with electrical connectors at its two ends. This superheater was installed in the steam supply line between the system of conventional traps and valves and the spray gun hose attachment. An alternating current electrical supply for the two superheater connections was operated at about 16.5 volts. The electrical resistance of the loop of tubing was such that about 65 amperes flowed, which was sufficient to superheat the steam to about 341° F. at about 70 pounds per square inch gauge pressure.

When this superheated steam was used for spraying the relatively viscous, unthinned enamel no water droplets were evident. The same skilled operator as in Example I applied a wet film of the relatively viscous enamel to a vertical metal panel in a quick industrial manner. After baking for 30 minutes at 280° F., the coating measured about 3 mils (0.003 inch) in thickness. It was smooth, uniform and glossy and showed no evidence of "sagging," "popping" or other surface irregularities commonly associated with thick or heavy one-coat films.

This invention employs dry steam resulting from deliberate addition of heat or from expansion of a relatively high quality steam under conditions which would leave it in the superheat range, i.e., above the saturation curve on a standard Mollier diagram. Of these two methods of superheating steam, the deliberate addition of heat is preferred because it is easier to control, and the potential degree of superheat is greater.

The degree of superheat required for applying various coating compositions under different conditions depends upon many factors; namely, original viscosity of the composition, atomizing pressure required, humidity, temperature, and velocity of the air surrounding the article to be coated, and the temperature of the article itself. However, for the practical finishing under normal industrial conditions, of merchandise subject to examination, minimum steam temperatures corresponding to at least 325—350° F. for about 70 pounds per square inch gauge pressure (about 85 pounds per square inch absolute) on a Mollier diagram are required. The latter conditions can be expressed as about 10 to 35° F. of superheat. The term "dry steam" is intended to refer to "super-heated steam" or to saturated steam of 100% quality. The optimum steam conditions for a specific spraying operation can easily be established by trial accompanied by corrective adjustments of steam temperature and pressure. For instance in Example II, the available adjustments include the original steam pressure, the setting of the reducing valve, length of the stainless steel resistance-type superheater, voltage and amperage applied to the superheater. and the standard adjustments available on the conventional spraying equipment used. An example of an adjustment is reducing the 125 pound per square inch steam to about 60 pounds per square inch gauge and leaving the superheater electrical supply unchanged. The resultant steam temperature was about 368° F., or about 60° F. of superheat. Any person skilled in applying enamel, lacquer, varnish, or the like, can easily adjust the system to a point where no undesirable condensed water droplets form.

The original quality of the steam is not critical. However relatively high quality steam, e.g., at least 95% is desirable because it responds to superheating more readily than lower quality steam.

Operation of the invention is not restricted to the equipment, pressures, temperatures, and coating composition of Example II. Any spray gun adaptable to or commonly used in applying coating compositions can be used, provided that its material of construction is resistant to the necessary steam temperatures and pressures. Such spray guns include external and internal mix; suction, gravity, and pressure feeds; single and multiple jet and others as described in The De Vilbiss Company's pamphlet "ABC of Spray Painting Equipment,"

copyright 1940.

All commonly used steam regulating traps, strainers, valves, and superheaters, adaptable to the range of pressures and temperatures required are usable, and no special accessories of this kind are necessary. The superheater, for instance, can be a heat exchanger, or it can be heated by direct flame, by products of combustion, by electrical induction, by electrical resistance, or by other heating means capable of producing the necessary degree of superheat. The shape or design of the superheater is not critical, provided it yields the desired results.

The nature of the auxiliary spraying equipment likewise is not critical. For instance, the coating composition can be supplied to the spray gun by suction, gravity or pressure, through the corresponding type of equipment. The equipment may be of the type adaptable to preheating the coating composition by conventional means before it reaches the spray gun, if additional viscosity reduction is necessary or desirable.

The operation of this invention is not restricted to the enamel used in the examples. All non-aqueous, substantially water insoluble organic coating compositions which are fluid at operating temperatures and are not adversely affected by the momentary elevation of temperature during atomization can be sprayed by the method of this invention. Such coating compositions include for instance, pigmented and clear finishes comprising the following vehicles, as such or in the various blends and combinations in common use; nitrocellulose lacquers, oil-modified alkyd resins, oleoresinous varnishes, water-insoluble vinyl or vinylidene resins, urea-formaldehyde and phenol-formaldehyde resins. Certain of these materials might require small quantities of thinning or reducing solvents to permit uniform flow from the storage vessel to the spray gun.

It is apparent from the foregoing examples and discussion that this invention represents a material advancement in the art of applying coating compositions. Heretofore, the thickness of a protective film applied to an article has been limited by the necessity of reducing or thinning the composition to spray viscosity. The thin composition would " pop " or " sag " when heavy coats were applied. The means of avoiding these difficulties were the application of several relatively thin films with an intermittent drying or baking period. This invention permits the application of considerably thicker coatings in one operation without " sagging " or " popping," reduces to a minimum or completely eliminates the use and cost of reducing or thinning solvents, eliminates several handling, drying and temporary storage steps in the process of coating various articles, and thus materially reduces the cost of coating the article. As pointed out in the examples, in the particular case of a white refrigerator enamel, this invention makes it possible to double or treble the thickness of the enamel film applied in one operation, thus reducing the handling, baking, temporary storage and spraying operations and costs by at least 50% to 66%. Also eliminated are the losses attendant to mixing and handling the thinned enamel. In its most useful aspects, this invention is used to establish a one-coat operation to replace a multiple-coat spraying process.

What we claim is:—

1. The process of applying a relatively viscous, non-aqueous, liquid organic coating composition as hereinbefore defined, which comprises atomizing the said composition into the form of a spray by means of steam which is at 10° to 60° F. of superheat, said composition comprising substantially water-insoluble organic film-forming material and substantially water-immiscible solvent therefor, and depositing the said atomized composition on a base in the form of a relatively thick uniform film.

2. Process as claimed in claim 1 which comprises feeding a stream of a coating composition consisting essentially of water-insoluble organic film forming material, water-immiscible solvent therefor and pigment, through an orifice and, as it emerges therefrom, atomizing the said composition by impinging a stream of the superheated steam against the said coating composition.

3. Process as claimed in claim 1 or 2 in which the steam is at 10° to 35° F. of superheat.

4. Process as claimed in claim 1, 2 or 3, in which the composition contains a urea-formaldehyde type resin.

5. Process as claimed in claims 1, 2 or 3 in which the coating composition contains an alkyd resin.

6. Process as claimed in claim 1, 2, or 3 in which the coating composition contains nitrocellulose.

7. Process as claimed in any of the preceding claims in which the steam is at about 75 pounds per square inch absolute pressure.

8. The process of applying a relatively

viscous, non-aqueous, liquid coating composition substantially as described.

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